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(54) WASTE TREATMENT AND PAPER FIBER RECLAMATION SYSTEM

(71) We, BLACK CLAWSON FIBRECLAIM, INC., of 200 Park Avenue, New York, State of New York 10017, United States of America, a corporation organised and existing under the laws of the State of Delaware, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The subject matter of the present application is related to that of copending Applications Nos. 17367/69 (Serial No. 1266420) and 45902/70 (Serial No. 1330665).

With the continuing increase in both population and per capita production of municipal refuse, the problem of disposing of municipal refuse is becoming a matter of increasing concern. For example, while the population of the United States has increased in the past fifty years from approximately 105 million to over 200 million, the per capita production of refuse in the United States has risen from a little over 2.5 pounds per day in 1920 to almost 5 pounds per day in 1970.

Traditionally, a major proportion of this refuse has been disposed of by either incineration or landfill while lesser amounts have been disposed of by methods such as dumping at sea and composting. Conventional incineration as a method of disposal, hwever, has met increasing resistance since it often results in pollution of the surrounding atmosphere with noxious fumes and fallout unless expensive and complicated gas treatment devices are utilized. Similarly, for conservation reasons disposal by dumping at sea is considered a less than desirable alternative. Accompanying the increase in population has been a parallel increase in the value of land. As a result, the expenditure required to acquire sufficient land for landfill purposes is becoming less and less economically feasible. Lastly composting, although it has been known for hundreds of years and has received intensive consideration for the past twenty to thirty years, has, for a variety of reasons, never become accepted as a primary method of disposing of refuse.

At the same time that both population and the per capita production of refuse have been increasing, the consumption of paper products has also shown a dramatic rise. Largely accountable for this rise has been the supplanting of metal, wood and glass as packaging materials by paper and the increased use of paper disposables such as paper cups, plates, napkins, and, in more recent years, garments and bedding. As a result, the proportion of municipal refuse constituted by paper products presently approaches, and in all likelihood will soon exceed, half of the total amount of such refuse. Thus the composition of typical municipal refuse by undried weight has recently been analyzed by American Paper Institute as follows:

Paper	46%
Garbage	12%
Grass and dirt	10%
Glass, ceramics and stones	10%
Metal	8%
Wood	7%
Textiles	3%
Plastic film	2%
Leather, molded plastic and rubber	2%

Analysis on an oven dry basis of municipal refuse treated in the development of the present invention indicated the following fractions:

Group I (Inorganic)	
Glass and Ceramics	13.5%
Metal	11%
Dirt	3%

Group II (Organic except Paper)	
Wood	1.5%
Grass and other vegetation	3.5%
Low Density plastics	3.0%
Textiles	2.0%
Molded plastic, leather and rubber	3.0%
Garbage (insoluble)	3.5%
Garbage (soluble)	4.0%
Group III (Paper)	52%
	100%

It will be seen, therefore, that the increase in both population and per capita production of refuse and the increased consumption of paper products present two problems which, based upon present projections, promise to become increasingly critical. Thus, the increased amount of refuse which must be disposed of renders conventional disposal methods less and less acceptable, while the necessity of developing greatly improved disposal techniques becomes increasingly critical as a result of the sheer volume of refuse being produced. At the same time, the dramatic rise in per capita consumption of paper products in the United States inevitably leads to the conclusion, backed by statistical analysis, that in the foreseeable future, the supply of virgin raw material will be exceeded by the requirements of the paper industry.

Another factor of particular importance to the present invention is the wide variety of paper products which commonly are present in municipal wastes, and which cover the full range from high grade virgin fiber used in products such as milk cartons, through all kinds of other papers and board to lower grade products such as egg cartons and other molded pulp articles. Thus, while attempts to separate some of the paper from the other constituents of municipal refuse have been attempted in the past, they have not proved to be practicable, in large part because the overall cost factor is too great for the potential value of the salvaged paper, and in part also because of the further difficulty of segregating paper of the better grades from other paper products. At the same time, one of the major difficulties encountered in conventional methods of refuse disposal is the extent to which paper products contribute bulk to the refuse far in excess of the proportion represented by their weight.

The present invention consists in a process for recovering paper fibers from refuse comprising:

(a) depositing in a treatment vessel an aqueous medium and refuse including:

(i) paper and other fibrous materials,
(ii) nonfibrous organics, and
(iii) inorganics

(b) reducing the fibrous and relatively frangible portions of said refuse to less than a predetermined particulate size by subjecting said refuse in the presence of the aqueous medium to substantial and violent mechanical and hydraulic shear forces while in said vessel,

(c) withdrawing from said vessel in slurry form said fibrous and relatively frangible portions below said predetermined particulate size and a portion of said aqueous medium.

(d) removing substantially all of said inorganics from said slurry by centrifugal cleaning while leaving substantially all of the organic material with the centrifugally cleaned slurry, and

(e) separating a substantial portion of the paper fibers from the other solid constituents of said slurry.

The invention also consists in a process of reclaiming paper fibers from municipal refuse which includes (i) waste paper products of many kinds and grades,

(ii) garbage and other non-fibrous organics and

(iii) inorganics, comprising:

(a) mixing the waste with an aqueous medium to a relatively dilute consistency,

(b) agitating the resulting mixture under conditions reducing the fibrous and other relatively frangible materials therein to a predetermined maximum particle size in slurry form in said medium while removing therefrom the relatively infrangible materials,

(c) removing at least the major portion of the inorganic particles from said slurry,

(d) separating the majority of the paper fibers of predetermined minimum lengths from the remaining solid constituents of said slurry and directing said separated long fibers to a first recovery station, and

(e) separating from the balance of said slurry the majority of the paper fibers of at least one other predetermined length range and directing said separated fibers to at least one other recovery station.

The invention further consists in apparatus for reclaiming paper fibers for reuse from municipal refuse comprising waste paper products of many kinds and grades mixed with garbage and other organics, and inorganics, comprising:

(a) a vessel for receiving the mixed refuse and an aqueous medium,

(b) means in said vessel for reducing the relatively frangible portions of said refuse to particles of less than a predetermined size,

(c) means for extracting from said vessel an aqueous slurry containing paper fibers and

the others of said relatively frangible particles below said predetermined particle size,

(d) centrifugal cleaner means connected to receive such slurry and to separate the same into accepted material including substantially all organics and rejected material including the majority of the inorganic particles in said slurry, and

(e) screening means connected to receive the accepted material from said cleaner means and adapted to reject therefrom the relatively coarse organic particles while retaining at least the major portion of the paper fibers of papermaking means size ranges therein.

By inclusion of the present invention, municipal refuse of the disparate character noted above is broken down into its various components or, in some cases, combinations of components, so that appreciable portions of the refuse are converted to useful products, and the remainder of the refuse is converted to forms amenable to ready disposal by a variety of methods. In particular an appreciable portion of the paper fibers, which constitutes the single largest component of the refuse, is reclaimed for reuse, thereby not only drastically reducing the amount of refuse which must be disposed of as waste, but at the same time providing a significant source of raw materials to satisfy the ever increasing consumption of paper products.

As a result, the present invention simultaneously provides a solution to both problems discussed above by, in effect, utilizing each problem to solve the other. Thus the increasing amount of refuse being generated provides a source of raw material for the paper industry to satisfy its increasing requirements, while the reclamation of paper fibers from refuse appreciably decreases the problem of waste disposal.

It has been suggested in the past that paper can be recovered from refuse wastes by a separating step performed in the dry or semi-dry state, for example, by a manual separating action or by air jets. In contrast, the practice of the present invention involves a wet process commencing with treatment of commercial refuse in aqueous suspension with, for example, a solids content of the order of 6%. This suspension is subjected to substantial and violent mechanical and hydraulic shear forces which reduce the frangible portions to particle sizes below a predetermined maximum. In the course of this initial treatment, the infrangible materials are readily removed from this suspension by appropriately controlled gravity action, and whatever stringy materials are not comminuted can also be separately removed.

The remaining original constituents of the refuse are transformed into an aqueous slurry which includes substantially all of the fibrous material along with most of the other materials listed above, except for a large part of the metal and perhaps the stringy materials, and in which the particles range in size up to approximately 1". The present invention is particularly concerned with the separation of this slurry into predetermined fractions of its original components and as much reusable paper fiber as possible in sufficiently clean condition for reuse. In a preferred embodiment of the invention, the major steps by which these results are accomplished may be summarized as follows:

(a) A centrifugal cleaning step to remove most of the balance of the inorganic materials which compose Group I above. The accepted material from this step is therefore primarily composed of paper and Group II materials listed above.

(b) Relatively coarse screening, for example, with 1/8" holes and advantageously with some defibering action. A relatively large fraction of the coarsest materials should be removed in this step.

(c) A finer screening step to reject organic particles accepted in the preceding step, for example, by means of 1/16" perforations. On the average, as large a percentage of the original materials, including fibers, is rejected in this step as in step (b).

(d) A centrifugal cleaning step designed to remove remaining high specific gravity particles and particularly directed to the elimination of particles of similar maximum dimensions and specific gravities but having irregular shapes as compared with paper fibers, such as coffee grounds, wood slivers, vegetation and particles of rubber, leather and plastic.

(e) A fiber selecting step, which is optional, directed to retention of a sufficient proportion of the relatively long fibers suitable for papermaking to establish an average length for the accepted fibers in the middle or preferably the higher portion of a range of .5 to 3.5 millimeters, a preferred example being those fibers longer than about 2 millimeters or of such lengths that they would normally be obtained on 35-mesh wire. A substantial portion of otherwise usable fiber should be rejected in this step in order to eliminate as much of the remaining garbage and vegetation as possible.

(f) As a further optional step the paper fibers may be recovered in selected fractions in accordance with their quality and/or other properties and the purpose for which they are to be used. For example, typical products which may be recovered in accordance with this feature of the invention will be pulp of two different grades, e.g. predominantly long fiber pulp capable of reuse in making a variety of papers, and predominantly intermediate length fibers capable of reuse as a substitute for used newsprint. Further, a use-

ful by-product of the invention comprises predominantly paper fiber fines and minute particles of food waste, and is therefore ideally suited for composting purposes. If this optional method is followed, therefore, the first fiber selecting step is followed by a secondary fiber selecting step directed to retention from the remainder of the slurry most of the fibers of intermediate length, e.g. those having an average length between .5 to 1.5 millimeters and which would therefore normally be retained on 100-mesh wire.

Additional steps, depending upon the conditions of the removed fiber, for purifying the fiber recovered by either of the fiber selecting steps, are further treatments such particularly as deinking by any standard technique, bleaching and/or sterilizing by treatment with steam under pressure in a digester. Treatment is a digester, particularly with a digesting agent, may also result in the elimination of nonfibrous organics.

Where paper fibers are recovered in selected fractions, the rejects from the secondary fiber selecting step or steps, which comprise mainly paper fiber fines and similarly small particles of food waste, may be dewatered for subsequent use as compost. Alternatively, these dewatered rejects may be incinerated, particularly in a fluid bed reactor, and their fiber content is helpful both in facilitating dewatering and in supporting combustion.

A further step which may be practiced and which is particularly effective where a high proportion of hairy materials, threads and light vegetable products such as leaves and grass are found is treatment in refining equipment at relatively low consistencies and tackle clearances followed by a flotation separation step and/or further centrifugal cleaning.

It is of particular importance to note in connection with each of the steps outlined above that for optimum results from the standpoint of quality of the ultimate product, it is usually necessary to reject a substantial portion of the paper fiber in the course of each step. While this statement may seem contrary to the ultimate purpose of the invention, the fact is that there is so close a relationship in size and specific gravity between the fibers to be retained and some of the particles to be eliminated that attempts to obtain maximum recovery of paper fibers tend to result in the retention of an unacceptably large portion of undesirable material, particularly particles of plastic, vegetation and textile fibers. Anomalous as is may seem, extensive experimentation in the development of this invention indicates that if in excess of 25%, and in some cases as high as 60%, of the paper fibres originally present in the slurry are eliminated in the course of the cleaning and screening steps, the retained fibers will be of a sufficiently high quality to warrant that amount of rejection. In contrast, if it is attempted to retain a significantly higher proportion of the paper fibers, the end product as a whole will be of such lower quality that the market for its reuse may not justify its recovery cost.

The invention accordingly offers the very practical advantage of substantial recovery of useful material from municipal refuse which currently is almost universally disposed of as wastes, and it has additional advantages with respect to the fractions of the starting refuse which are separated from the paper fibres. Thus the heavy metals initially removed in the course of the pulping step can be salvaged, and the gritty constituent removed in the first centrifugal cleaning step may also have salvage value, for example, as aggregate. Alternatively, in areas where glass is the major constituent of the gritty materials, it may be salvaged for its own value, and any such salvage operation is aided by the fact that the gritty materials are removed in a condition which is relatively clean and free from contaminating materials. Obviously these gritty materials can also be easily disposed of as landfill, and their relatively sanitary condition makes them particularly useful for localized fill purposes, such as building operations, for which they could not be used if mixed with other materials as part of untreated refuse.

The fractions which are rejected in the successive screening steps, and particularly the rejected material from steps (b) and (c), can be used by themselves as source material for usable products such as building board. This result is enhanced by the fact that these rejected fractions contain a relatively high proportion of thermoplastic resins which have a strong bonding effect on the retained paper fibers under heat and pressure to produce a relatively hard and stable board product. If, however, the particular community practicing the invention prefers to dispose of this material by combustion, this treatment also is easy to carry out after sufficient dewatering, and both the retained fiber and the plastic contribute to this result.

The invention accordingly provides, and its main object is to provide methods and apparatus for the treatment of municipal wastes which result in substantial recovery of paper fibers and which result also in separation of the major other components of municipal wastes into fractions which are either readily adapted for reuse of which are in particularly advantageous condition for ultimate disposal as waste.

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings, in which:—

Fig. 1 is a flow diagram illustrating the

apparatus and process steps of the present invention;

Fig. 2 illustrates a modification of the process and apparatus of Fig. 1;

Fig. 3 shows a further modification of the process and apparatus of the present invention;

Fig. 4 illustrates graphically the desired relationship between tackle clearance and slurry consistency when passing the slurry through a refiner or the like; and

Fig. 5 is a flow diagram illustrating apparatus and process steps for recovering fibers in selected fractions.

As seen in Fig. 1, a system according to the present invention includes a treatment vessel 10 having a rotor 11 rotatably mounted therein and carrying outwardly projecting arms 12 which in turn carry pivotally mounted hammers or flails 13. A conveyor 14 is provided for carrying refuse to the vessel 10, and a junk remover 15 is positioned adjacent the vessel and in communication therewith by means of the conduit 16. An extraction plate 17 is mounted in the bottom of vessel 10 and is provided with perforations of predetermined size so that only particles of sizes sufficiently small to pass therethrough are extracted to a discharge chamber (not shown) therebelow. At this stage, it is desirable to extract relatively large particles, and holes of 1" diameter in the plate 17 have been found satisfactory. The equipment thus far described may be of the same general type as that described in the specification of our copending application No. 45902/70 (Serial No. 1330665), and U.S. Patent No. 3,439,092 and it reduces the waste to an aqueous slurry containing all of the original waste except the infrangible material removed by junk remover 15 and whatever stringy materials are effectively removed from vessel 10.

In operation, the conveyor 14 continuously deposits municipal refuse in the vessel 10 where it is treated by the rotor with the flails or hammers 13 on its arms 12. The refuse deposited in the vessel 10 will consist of fibrous materials such as paper, textiles, grass and wood, non-fibrous organic material such as plastic film, leather, molded plastic, rubber and garbage and inorganics such as dirt, glass, ceramics, stones and metal. Liquid is supplied by a line 18 through the junk remover 15 and its connecting conduit 16 into the vessel 10, and the arms 12 and hammers or flails 13 subject the resulting mixture of refuse and liquid to substantial and violent mechanical and hydraulic shear forces and thereby comminute the relatively frangible portions of the refuse.

Relatively infrangible materials, such as iron castings, metal cans and the like, are removed separately from the vessel 10 by means of the junk remover 15 for disposal by any convenient means such as landfill, and the supply of liquid by way of the junk remover 15 tends to wash fiber and other light material back into vessel 10 so that the removed metal is relatively clean. Of course, salvageable metals such as copper, lead and ferrous products, may be removed before disposal of the remainder of the infrangibles. The remaining, relatively frangible materials are comminuted by the arms 12 and flails 13 and the hydraulic shear forces set up in the vessel until they are of sufficiently small size to pass through the openings in the extraction plate 17 in the bottom of the vessel 10.

The materials extracted from vessel 10 in aqueous slurry form are pumped by a pump 20 to a centrifugal cleaner 22, which performs step (a) as outlined above. That is, it separates substantially all of the inorganics, such as metals, glass and stones from the remainder of the slurry, and in practice it has been found that the weight of reject removed at this stage will on the average be approximately equal to that removed by the junk remover 15. The rejects are conveyed from the cleaner 22 as indicated at 21 for disposal either by landfill methods or for example, use as an aggregate in concrete or asphalt. Additionally, the glass may have salvage value as cullet.

The accepted material from the cleaner 22, which includes substantially all of the organic materials, is passed to a holding tank 23 from which a pump 24 delivers the slurry to coarse screening apparatus 25, and the accepted slurry from the coarse screen 25 is passed onto a relatively fine screen 26. The screen 25 may be of the same general type as that shown in U.S.A. patent No. 2,033,123, while screen 26 may be of the type shown in U.S.A. patent No. Re. 24.677, although it will be apparent that other types of screening equipment may be utilized to perform the successive coarse and fine screening steps (b) and (c) as outlined above.

In operation, the screen 25 will separate a substantial portion of the reusable papermaking fibers in the slurry from the other constituents, such particularly as a major part of the wood and other vegetation, textiles, plastic, coarse food wastes, metal foil, rubber, leather and undefibered wet strength paper. These reject materials are indicated as carried by a conduit 29 to a secondary screen 30. As previously noted, satisfactory results have been obtained with a screen 25 having an effective retaining action on particles larger than about .125 inch in any direction, and it should also be noted that the screen 25 may advantageously be of a type which will impart some defibering action to bundles of reusable fibers in the course of its screening action.

The finer screen 26 will remove reject

particles similar to those removed by the screen 25 but which are of too small particle sizes to be retained by the screen 25. Thus as already noted, if the perforations in coarse screen 25 are of the order of .125 inch, those in fine screen 26 may be .0625 inch in diameter. The rejects from the screen 26 are also conveyed by the conduit 29 to the secondary screen 30. Accepts from screen 30 are shown as returned to the holding chest 23 for recirculation through screens 25 and 26, while rejects from screen 30 are conveyed to an agitator chest 31 provided with an agitator 32.

Screens 25 and 26 are preferably selected such that the fibers which pass these two screens includes most of those having a length in the range of .5—3.5 millimeters, and that undefibered rags and long synthetic fibers are rejected particularly by screen 25, but the accepted stock also includes substantially all of the short fibers and fines. If it is desired to reduce the proportion of these fines and other small particles having a maximum dimension of less than 1 millimeter, fiber selector means are utilized which will accept the longer fibers and will reject fines and other small particles. The fiber selector may be positioned downstream of the screen 26 to receive the accepts therefrom, but preferably the accepts first pass to a series of centrifugal cleaners.

Thus, a holding tank 32 receives the accepts from screen 26 and make up water from a water supply 33 and a pump 34 pumps material from the holding tank 32 to a bank of centrifugal cleaners 35. Cleaners 35, which are connected in parallel, deliver accepted material to a common discharge conduit 36. The cleaners 35 are of the same general type as the cleaner 22, which removed substantially all of the inorganics, but are designed to impart higher centrifugal forces to remove not only the relatively small portion of fine inorganics such as glass, metal, dirt and sand which passed a cleaner 22, but also odd-shaped organic particles similar in specific gravity and such as coffee grounds, wood slivers, vegetation, particles of rubber, leather and the like. These reject materials are conveyed from the cleaners 35 by a common line 37 and a pump 38 to secondary centrifugal cleaners 39 (one being shown) from which the accepts are recirculated through a line 40 back to the holding chest 32, and the rejects are carried by a line 41 to the agitator chest 31.

The accepted slurry from the cleaners 35 is delivered by line 36 to fiber selecting apparatus 42 of any suitable construction which is effective to select relatively long fibers from a slurry of fibers of various lengths and other particulate materials. Reference may be had to U.S. Patent No. 1,786,973, issued December 30, 1930 for several types of apparatus for this purpose. Satisfactory results have also been obtained with various thickening devices used in the papermaking industry and provided with a screening member having perforations or slots sized to retain fibers of the desired range of lengths while passing fines of all kinds as reject, for example, 80 mesh perforations. The slurry is preferably relivered to the selecting apparatus 42 at a dilute consistency and the retained accepted stock is transmitted to a dewatering device 43 while the reject is passed to a clarifier chest 44 to which further reference is made hereinafter.

As noted above, the fiber selector 42 is utilized only if fibers to be reclaimed are desired to have an average length in a particularly high range. Otherwise, the fiber selector 42 is unnecessary. It should also be noted that although the fiber selector 42 is illustrated as positioned downstream of the cleaners 35, it may be positioned instead upstream of these cleaners. If positioned upstream, the load on the cleaners is less, but if positioned downstream, the cleaners will remove some fines and the load on the selector will be less. Additionally the fiber selector has a dewatering effect. Since the centrifugal cleaners 35 operate at low consistencies it would be necessary to dilute the accepts from the fiber selector before feeding them to the cleaners 35. Also, the material delivered to thickener 43 should be prethickened to avoid undue fiber loss during treatment by the thickener 43. Hence it will usually be preferable to place the fiber selector downstream of the cleaners 35.

The accepted material from the fiber selector 42 is conveyed to the dewatering station 43 and an additional dewatering device 50 connected in series to increase the consistency of the slurry in a two-step process. For example, the device 43 may be of the screw thickener type while the dewatering device 50 may take the form of a dewatering press, and the liquid removed thereby is carried by a common line 52 to the clarifier chest 44. The dewatered material from devices 43—50 is conveyed by line 53 to a suitable feeding device 54 of, for example, the screw feeding type, which delivers the relatively high consistency material to a digester 55 for performing a digesting step as outlined above. Digester 55 is preferably of the continuous type which subjects the material to be treated to heat and superatmospheric steam pressure as it passes therethrough to disperse or dissolve grease, asphalt, printing ink and the like.

It is likely that the material delivered to the digester 55 will contain some residual food waste and vegetation, such as grass clippings, in addition to contaminants like ink, resins and petrochemicals such as asphalt. The action of the digester tends to

disperse the latter materials, but if the contaminants remaining in the slurry comprise any substantial amount of food waste and vegetation, it is desirable to add a digestion chemical, such as sodium hydroxide. If the remaining contaminants comprise a significant amount of synthetic resins and/or petrochemicals, the material may be treated in the digester with a volatile solvent such as trichloroethylene which will dissolved the contaminants and cause them to be dispersed in non-objectionable form throughout the fibers when the solvent is flashed off after discharge from the digester.

The material discharged from the digester 55 is conveyed to a holding tank 56 from which it is pumped by a pump 57 to a washer 60 to which water or other washing liquid is supplied at 59. The washed material from the washer 60 is conveyed to a press 61 for dewatering, and thence to a station 62 equipped with a baler or other apparatus by which it is prepared for shipment to a further point, or the station 62 may represent a paper machine when the reclaimed fibers are to be reused. in which case the press 61 would not be needed in the system. The wash liquid from the washer 60 is taken to a holding chest 63 from which some is returned by a pump 64 to the holding tank 56, and the balance is removed from the system at 65 for disposal. The liquid removed by the press 61 is relatively clean, and it may be recycled to other parts of the system for reuse as desired, for example to the vessel 10 as shown.

As noted above, the rejects from the screens 25 and 26 and the centrifugal cleaner 39 are conveyed to an agitator chest 31. Since essentially all of the inorganic materials have been removed from the system by the junk catcher 15 and the centrifugal cleaners 22 and 35, the material deposited in the agitator chest 31 will consist, for the most part, of organic material, although there may be a minor portion of inorganics. The agitator 32' in the chest 31 maintains these solids in suspension, and the suspension is withdrawn from the chest 31 by a pump 66 and pumped to a dewatering device 67, which may conveniently be of the screw thickener type.

The partially dewatered solids from the thickener 67 may be conveyed by a conduit 68 to a bank of presses 70 which serve to dewater the material further in preparation for final disposal by any convenient means, shown as a fluidized bed reactor 71 in combination with a blower 72. Since the material fed to the fluidized bed reactor will be mainly organic materials, oxidation thereof by the reactor will be substantially complete, and only a minor portion of the material will remain after the reaction for further disposal.

Liquid removed by the dewatering devices 43, 50, 67 and 70 will be accompanied by some solid material. Therefore, this liquid is preferably conveyed to the clarifier 44. A major portion of the clarified liquid from the clarifier 44 is conveyed to a water chest 75 from which it is pumped by a pump 77 through a conduit 78 back to the water inlet 18 to the waste treatment vessel 10.

To prevent the liquid recirculated to vessel 10 from becoming too rich in suspended and dissolved solids, a portion of the liquid from clarifier 44 is bled from the system at 80 for disposal. An additional outlet 81 is provided from the clarifier 44 so that relatively high consistency materials from the clarifier may be pumped by a pump 82 to a filter 83. Solid material removed by filter 83 is conveyed by line 84 to the presses 70, from which it may be disposed of by any convenient means such as fluidized bed reactor 71. Liquid from the filter 83 is returned to the clarifier 44 by the line 85.

As noted above, if the material delivered to the digester 55 includes, in addition to reusable papermaking fibers of the desired size, contaminants in the form of synthetic resinous materials and petrochemicals, it may be desirable to treat the fibers with a volatile solvent such as trichloroethylene prior to washing and further dewatering thereof. Fig. 2 illustrates this modification of the invention wherein the line 53 conveys the fibrous material and contaminates to the screw feeder 54 while trichloroethylene or the like is fed through a line 88 into the digester 55. As the fibers and attached contaminants are mixed with the solvent and travel through the digester, the contaminants are dissolved and dispersed throughout the fibers. The material from the digester is then passed to a blow tank 90 from which the volatile solvents may be recovered through the line 91 while the fibers with the contaminants dispersed throughout are ejected to the chest 56 for further treatment as above.

It should also be noted that, whereas the material from the presses 70 is described as being oxidized by means of a fluidized bed reactor or the like, this material is high in organic content and might instead be thickened and used as compost or fortified with nutrient and used for animal food. Additionally, as shown in dashed lines in Fig. 1, the material from presses 70 might be conveyed to a heated platen press 95 where it is treated with heat and pressure to form hardboard.

It has been found that relatively large particles of relatively light materials often have a tendency to become entrapped with the papermaking fibers. For example, in treating municipal refuse in the fall of the year leaves will constitute, for some communities, an appreciable portion of the refuse. Similarly, grass clippings, and trimming from shrubbery

and the like will constitute a portion of the refuse collected during the spring and summer months. These particles and other, hairy material, such as hairs and threads, can be readily taken care of by a step somewhat similar to refining, although with important differences as noted below, followed by a froth flotation separating step and/or a centrifugal cleaning step.

Thus, as seen in Fig. 3, the slurry of material at a relatively low consistency is directed to refining apparatus 100 of, for example, the disc type, operating at relatively narrow clearances between the refiner tackle to cause large particles such as hairs, threads, leaves and blades of grass to be broken up. Since the fibers of the slurry are separated and the slurry is at arelatively low consistency, even though the clearances in the refining apparatus are quite narrow the paper fibers are able to pass through the refining equipment with negligible working thereof while the larger particles of the foreign materials referred to above are broken down into smaller particles. This can be noted with respect to Fig. 4 where it is shown that the refiner can even be run with the tackle, such as opposed refining plates, just touching as long as the consistency is kept well below 1%. Of course, if the tackle clearances are increased the consistency may also be increased, as indicated by the curve of Fig. 4, although at some sacrifice of efficiency in reducing the larger particles. Thus, in order to maintain a relatively constant hydration level the consistency and tackle clearances must be varied as shown.

It will be apparent that the refining step may be performed at a number of places throughout the system shown in Fig. 1 of the drawings. Thus, the material from pump 34, instead of being pumped to the cleaners 35, could be directed to the refiner 100 for treatment as described above, Alternatively, the accepts from the cleaners 35 could be passed to the refiner 100. Preferably, however, the refiner 100 will be positioned downstream of the digester 55 so that any material, such as hair, threads or light vegetable materials remaining after treatment by the unit 55 can be broken up by the refiner 100.

From the refiner 100 the foreign materials which have been comminuted by the refiner 100 and the fibers may be directed to a flotation tank 102 which may operate on well known froth flotation principles, with or without the addition of an appropriate chemical agent, to cause at least certain portions of the foreign materials to be separated from the paper fibers. The froth flotation step may then be followed by an additional centrifugal cleaning step to further remove any foreign materials, particularly those which were broken up in the refiner and now are easily separated in the centrifugal cleaner 104 from the fibers and ejected therefrom separately from the fibers.

It will be noted that the two-step treatment of the material from the refiner 100 may be unnecessary since the treatment by the flotation unit 102 alone may be enough. Additionally, the material from the refiner 100 may be passed thorugh a holding tank 106 and thence, directly to the centrifugal cleaner 104, thereby bypassing the flotation unit 102. However, since the froth flotation unit may be utilized to separate, not only the foreign materials discussed above but such things as ink, grease and asphalt, it will usually be desirable to include this unit.

With reference to Fig. 5 of the drawings a further feature of the present invention will be described wherein paper fibers are recovered for reuse in selected fractions. The basic components of the system of Fig. 5 are the same as their counter-parts shown in Fig. 1 and includes a treatment vessel or pulper 10 to which municipal refuse is delivered without preliminary treatment. Pulper 10 is generally of the type used in the paper industry, preferably constructed in accordance with the disclosures of either U.S. Patent 3,339,851 or the above noted copending application No. 45902/70 (Serial No. 1330665). Thus the pulper includes a rotor 11 mounted therein on a vertical axis and comprising outwardly projecting vanes or arms 12 having hammers or flails 13 pivotally mounted thereon. A conveyor 14 carries solid materials to the pulper or tub 1 and is preferably constructed to receive municipal refuse directly from the collecting trucks of the municipality.

As in the system shown in Fig. 1, the conveyor 14 deposits municipal refuse in the tub 10 where it is treated by the rotor with the flails or hammers 13 on its vanes 12. The refuse deposited in the tub 11 will consist of fibrous materials such as paper, textiles and wood, non-fibrous organic materials such as plastic film, leather, molded plastic, rubber, garbage and grass, and inorganics such as dirt, glass ceramics, stones and metal. Liquid is continuously supplied to the tub 10 to maintain the solids content sufficiently low for effective pulping, e.g. 6%, and the vanes 12 and hammers or flails 13 subject the resulting mixture of refuse and liquid to substantial and violent mechanical and hydraulic shear forces and thereby comminute the relatively frangible portions of the refuse.

Relatively infrangible materials, such as iron casting, metal cans and the like, are removed separately from the tub 10 by the junk remover 15 through the conduit 16 for disposal by and convenient means such as landfill. Salvageable metals such as copper, lead and ferrous products, may be removed before disposal of the remainder of the in-

frangibles. The remaining, relatively frangible materials are comminuted by the vanes 12 and flails 13 and the hydraulic shear forces set up in the tub until they are of sufficiently small sizes to pass through the openings in the extraction plate 17.

The materials extracted from vessel 10 in aqueous slurry form are pumped by a pump 20 to a centrifugal cleaner 22, which performs step (a) as outlined above. That is, it separates substantially all of the inorganics, such as metals, glass and stones from the remainder of the slurry, and in practice it has been found that the weight of reject removed at this stage will on the average be approximately equal to that removed by the junk remover 15. The rejects from the cleaner 22 are relatively clean and of uniform size, the majority being pieces of glass of an average size slightly smaller than the perforations in extraction plate 17 and therefore well suited for recovery for reuse in the glass industry. Alternatively, this reject may be disposed of by landfill methods or, for example, used as an aggregate in concrete or asphalt.

The accepted material from the cleaner 22, which includes substantially all of the organic materials, is passed to a holding tank 23 from which a pump 24 delivers the slurry to screening apparatus 25. While for purposes of simplification the drawing shows a single screen 25, two screens or sets of screens in series, as in Fig. 1 of the drawings, are preferably used, the second stage being substantially finer than the first. For example, the first screen may be of the same general type as that shown in U.S. Patent No. 2,033,123 and provided with openings having effective diameters of the order of .125 inch, while the second screen may be of the type shown in the U.S. Patent No. Re 24,677 and provided with .0625 inch openings.

In operation, the screening apparatus 25 will separate as large a proportion as possible of the reusable paper fibers in the slurry from the other constituents, such particularly as a major part of the wood and other vegetation, textiles, plastic, coarse food wastes, metal foil, rubber, leather and undefibered wet strength paper. These reject materials are indicated as carried by a conduit 27 to a waste treatment facility 28 such as a settling tank. If it is found desirable to reject a substantial portion of the paper fibers in order to assure effective screening of contaminants from the accepted fiber, a secondary or tailing screen can be connected between screening apparatus 25 and tank 28 to return its accepts to the holding tank 23 for recycling to screening apparatus 25.

The accepted slurry from the screening apparatus 25 is delivered under appropriate pressure to a cleaning station represented by the centrifugal cleaner 130, which may be of the same general type as the cleaner 22 but designed to impart higher centrifugal forces to remove not only the relatively small portion of fine inorganics such as glass, metal, dirt and sand which passed cleaner 22, but also odd-shaped organic particles similar in specific gravity and maximum dimensions to paper fibers, such as coffee grounds, wood slivers, vegetation, particles of rubber, leather and the like. These reject materials are conveyed from the cleaner 130 by a line 131 to the settling tank 28.

The accepted material from the cleaner 130, which comprises primarily paper fibers of all sizes, is delivered by a line 132 to primary fiber selecting apparatus 133 of a construction and mode of operation effective to select the relatively long fibers from the slurry. According to one preferred embodiment of the invention, the primary fiber selecting apparatus 133 may be designed and controlled to retain as large a proportion as possible of the fibers which would normally be retained on 35-mesh wire, and which are therefore primarily in the length range upwards from 2 millimeters and have a freeness of at least 400. For this result, fiber selecting apparatus which has proved satisfactory includes a side hill washer or inclined screen having a screening surface equivalent in operation to 35-mesh wire. Another example of satisfactory apparatus is a "DMS" screening unit sold by Dorr-Oliver, Inc.

The retained or accepted fiber from fiber selector 133 is conveyed to one or more further processing stations indicated generally at 135. For example, the station 135 may include dewatering apparatus such as screws and a press, and the dewatered fiber may then be baled for shipment to its point of reuse. If this fiber needs further purification, the station 135 may incorporate deinking and/or bleaching apparatus of any type conventionally used in the paper industry, and it may also include means such as a digester for sterilizing the fiber by subjection to steam pressure, with or without chemical agents, for dispersing any food particles or other contaminants which might be present.

The material rejected by the fiber selecting apparatus 133, which will include the great majority of the fines and paper fibers of intermediate lengths, are transmitted by a line 139 to secondary fiber selecting apparatus 140 effective to separate the intermediate length fibers from the fines and other small particles. The stock delivered to the apparatus 140 will usually include most of the hard wood and ground wood fibres originally present in the municipal refuse, since most of the kraft and sulfite fibers are in the longer length category separated by the apparatus 133. In accordance with the present example of the invention, the fiber selec-

tor 140 should retain as much as possible of the fibers longer than about .5 millimeter, and the retained fibers will usually have an average length of .5 to .15 millimeter and a freeness of the order of 250—300. These fibers will therefore be of the sizes normally retained on 100-mesh wire while most of the fines will pass along with the other small particles.

Satisfactory results in the practice of this embodiment of the invention have been obtained with a side hill washer having a screening surface equivalent in operation to 100-mesh wire. The fibers retained by the selector 140 are shown as transmitted to further processing stations 142 which may include any or all of the pieces of apparatus already described in connection with the further station 135. The material rejected by the selector 140, comprising predominantly paper fiber fines and similarly small particles of food waste or other garbage, is delivered to the line 131 leading to the settling tank 28 for mixture with the rejects from the screening apparatus 25 and cleaner 130. Alternatively, if it is desired to separate the reclaimed fibers into more than two fractions, one or more further fiber selecting stations can be connected in series to receive and separate the slurry rejected by the selector 140, with only the finally rejected material being delivered to the settling tank 28.

Conservation of water is promoted by recycling clarified water from the settling tank 28 to other locations in the system where it is needed, such particularly as the pulper 10 and the holding tank 23, as indicated by the line 143. The solid particles which settle out of the water in tank 28 form a sludge which is discharged through line 144 to a dewatering station 145 such as a battery of dewatering screws and a press, from which the dewatered material is conveyed to an incinerator 150 such particularly as a fluid bed reactor. The exhaust gases from the incinerator are transmitted to suitable cleaning apparatus 151, such as a wet venturi scrubber, where the ash is dewatered for final disposal, which may be as landfill with the washed rejects from the junk remover 16 and the cleaner 22. Alternatively, this ash may be recovered for use with or as a substitute for flyash.

The advantages of the system and method of the invention as described above will now in large measure be apparent. In evaluating the invention, it is important to recognize that it is directed to the performance of a task which is essential for every municipal community, namely the disposal of its refuse, which task represents a significant part of the cost of maintaining each such community even without the continuing increase in the production of refuse already discussed above. The value of the invention can therefore be measured in terms of the extent to which it contributes to the control or reduction of the costs of refuse disposal, and judged on this basis, the invention offers the following advantages.

(1) The material requiring final disposal as waste is reduced to a minimum.

(2) The material requiring final disposal as waste is provided in particularly convenient condition for such final disposal.

(3) The major components of municipal refuse are classified for separate further processing in the most expeditious ways.

(4) Salvage of the heavy components of municipal refuse, both metals and nonmetals, is facilitated by their separation in relatively clean condition for further processing.

(5) The paper fibers which now constitute a major portion of municipal refuse are reclaimed in a condition of sufficiently high quality for resale at prices which will significantly contribute to defraying the overall cost of municipal refuse disposal.

(6) The invention can be practiced by means of suitably controlled combinations of selected equipment of currently conventional construction.

The last two of these advantages contribute a factor to the practice of the invention which makes it of significant importance to control the several separating steps in such manner as to assure the recovery of reusable paper fibers in a condition of relatively high quality. A complication in achieving this objective derives from the close relationship of particle size and specific gravity between many of the paper fibers and some of the common constituents of municipal refuse which would be contaminants if not eliminated from the reclaimed fibers. The invention therefore recognizes this problem and avoids it in practice by controlling the successive separating steps to eliminate a sufficiently large fraction of the fibrous materials at each stage to assure that adequate elimination of the contaminants is achieved. As a result, after complete processing, over 25% of the fibers originally present in the refuse fed into the system have been rejected and, depending upon the quality of fibers desired, this may run as high as 60%, although an optimum figure is approximately 40%.

With regard to the quality of fibers recovered, practice of the invention as described in Fig. 5 will result in the production of two types of paper fiber of good quality for reuse. The long fiber separated out at the primary fiber selector 133 will comprise most of the long chemical fiber (kraft and sulfite) and will be ideal for reuse to make products such as ninepoint corrugating medium or base liner, and if deinked and possibly bleached, it will also be usable for making fine papers. The fiber separated out of the

secondary fiber selector 140 will comprise mostly hard wood and ground wood, and it may be reused wherever used newsprint is used. It will also be apparent that principles of the invention can be employed with different or greater selectivity from the wide variety of fibers present in municipal refuse, depending upon the particular markets to which the reclaimed fiber is to be supplied, and specifically that the number and selectivity of the fiber selecting stations can be increased to produce a correspondingly increased number of reclaimed fractions of paper fiber for reuse.

Even though a relatively high percentage of paper fibers are rejected this does not represent a total loss. Thus if the rejects are used for the production of building board as described, the paper fibers will be the major constituent of that board, in combination with the plastic which binds them together. Furthermore, even if the rejects are ultimately burned, that operation is facilitated by the presence of the paper fibers, both in the manner in which the aid dewatering before burning, and also by reason of their inherent B.T.U. content. In this connection, it should also be noted that the reject prepared for incineration in the fluad bed reactor 71 can advantageously be mixed with sewage sludge and the resulting mixture then incinerated.

WHAT WE CLAIM IS:—

1. A process for recovering paper fibers from refuse comprising:

(a) depositing in a treatment vessel an aqueous medium and refuse including

(i) paper and other fibrous materials,
(ii) nonfibrous organics, and
(iii) inorganics

(b) reducing the fibrous and relatively frangible portions of said refuse to less than a predetermined particulate size by subjecting said refuse in the presence of the aqueous medium to substantial and violent mechanical and hydraulic shear forces while in said vessel,

(c) withdrawing from said vessel in slurry form said fibrous and relatively frangible portions below said predetermined particulate size and a portion of said aqueous medium,

(d) removing substantially all of said inorganics from said slurry by centrifugal cleaning while leaving substantially all of the organic material with the centrifugally cleaned slurry, and

(e) separating a substantial portion of the paper fibers from the other solid constituents of said slurry.

2. The process of claim 1, comprising the further step of rejecting from said slurry a substantial proportion of all particles having a maximum dimension of less than 1 millimeter.

3. The process of claim 1 or 2, wherein said operation of separating a substantial portion of said paper fibers from said slurry comprises screening said slurry in a series of progressively finer screen means.

4. The process of claim 3, wherein said screening operation comprises:

(a) passing said centrifugally cleaned slurry through a coarse screen; and

(b) passing the resulting coarsely screened slurry through a second screen having a relatively fine mesh with respect to said coarse screen.

5. The process of claim 3 or 4, comprising the further step of subjecting said screened slurry to further centrifugal cleaning under controlled conditions effecting the rejection of irregularly shaped particles of organic materials similar in specific gravity to paper fiber.

6. The process of any preceding claim, comprising the further step of dissolving or dispersing a substantial portion of any nonfibrous organics remaining with the paper fibers separated from said centrifugally cleaned slurry.

7. The process of claim 6, wherein said dissolving step comprises subjecting the paper fibers and remaining organics with heat at superatmospheric pressure and at least one chemical agent.

8. The process of claim 7, wherein said chemical agent is an organic solvent, and comprising the further step of evaporating said solvent to leave material dissolved thereby dispersed in finely divided state throughout the accepted paper fibers.

9. The process of claim 1, wherein said operation of separating a substantial portion of paper fibers from the other solid constituents of said slurry comprises:

(a) subjecting said centrifugally cleaned slurry to a relatively coarse screening operation effecting the rejection therefrom of the relatively coarse organic particles and a substantial portion of said paper fibers; and

(b) subjecting said screened slurry to a finer screening operation effecting the acceptance of the majority of the paper fibers while rejecting a substantial portion of said fibers and of the other organic particles accepted in the preceding screening operation.

10. The process of claim 9 comprising the additional step of so controlling the proportions of accepted and rejected material during said coarse and finer screening operations that paper fibers constitute in the order of 25—60% of all material rejected in said screening operations.

11. The process of claim 9 or 10, comprising the further step of removing from the material accepted in said coarse and finer screening operations a substantial portion of

all particles having a maximum dimension of less than one millimeter and with paper fibers constituting a substantial portion of such removed particles.

12. The process of claim 11, comprising the further step of subjecting the accepted material to further centrifugal cleaning under controlled conditions effecting the rejection of irregularly shaped particles of organic materials similar to paper fibers in specific gravity and maximum dimension.

13. The process of claim 11 or 12, comprising the further step of subjecting the accepted material to a digesting operation effective to dissolve or disperse a substantial portion of any nonfibrous organics remaining therein.

14. The process of any preceding claim, characterized by so controlling each of the steps defined that the finally accepted paper fibers constitute less than approximately 60% of the paper fibers initially present in said refuse.

15. The process of any preceding claim, wherein said separating step includes:

(a) screening said centrifugally cleaned slurry,

(b) directing the resulting screened slurry at relatively low consistency through a refiner operating at relatively close tackle clearances.

16. The process of claim 15, further comprising:

(a) directing said slurry from said refiner to a flotation tank, and

(b) separating paper fibers from other constituents of said slurry in said flotation tank.

17. The process of claim 16, further comprising centrifugally cleaning said paper fibers from said flotation tank.

18. The process of claim 15, 16 or 17, further comprising centrifugally cleaning said slurry from said refiner.

19. The process of claim 15, 16, 17 or 18, wherein said slurry is directed through said refiner at .10% to 1% consistency.

20. The process of claim 15, 16, 17, 18 or 19, wherein said tackle clearances are less than .020 inches.

21. The process of claim 1 wherein said separating step comprises including with said other solid constituents in excess of 25% of the paper fibers.

22. The process of claim 21 wherein approximately 25—60% of said paper fibers are included with said other solid constituents.

23. The process of claim 21 wherein approximately 40% of said paper fibers are included with said other constituents.

24. The process of reclaiming paper fibers from municipal refuse which includes (i) waste paper products of many kinds and grades, (ii) garbage and other non-fibrous organics and (iii) inorganics, comprising:

(a) mixing the waste with an aqueous medium to a relatively dilute consistency,

(b) agitating the resulting mixture under conditions reducing the fibrous and other relatively frangible materials therein to a predetermined maximum particle size in slurry form in said medium while removing therefrom the relatively infrangible materials,

(c) removing at least the major portion of the inorganic particles from said slurry,

(d) separating the majority of the paper fibers of predetermined minimum lengths from the remaining solid constituents of said slurry and directing said separated long fibers to a first recovery station, and

(e) separating from the balance of said slurry the majority of the paper fibers of at least one other predetermined length range and directing said separated fibers to at least one other recovery station.

25. The process of claim 24, wherein the average length of the paper fibers separated in step (d) is greater than 2 millimeters and wherein the average length of the paper fibers separated in step (e) is in the range of .5 to 1.5 millimeters.

26. The process of claim 24, wherein the majority of the paper fibers separated in step (d) are of the lengths normally retained on 35-mesh wire and wherein the majority of the paper fibers separated in step (e) are in the lengths normally retained on 100-mesh wire.

27. The process of claim 24, 25 or 26, wherein the solid materials remaining in the slury following step (e) comprise primarily paper fiber fines and small particles of garbage.

28. The process of claim 24, 25, 26 or 27, comprising the step of subjecting the slurry remaining after step (c) to centrifugal cleaning under controlled conditions effecting the removal therefrom of irregularly shaped particles of organic materials similar to paper fibers in specific gravity and maximum dimension.

29. The process of claim 24, 25, 26, 27 or 28, comprising the step of subjecting the paper fibers separated in at least one of steps (d) and (e) to further purifying treatment.

30. The process of claims 29, wherein said purifying treatment comprises deinking and/or sterilizing.

31. Apparatus for reclaiming paper fibers for reuse from municipal refuse comprising waste paper products of many kinds and grades mixed with garbage and other organics, and inorganics, comprising:

(a) a vessel for receiving the mixed refuse and an aqueous medium,

(b) means in said vessel for reducing the relatively frangible portions of said refuse to particles of less than a predetermined size,

(c) means for extracting from said vessel an aqueous slurry containing paper fibers and

the others of said relatively frangible particles below said predetermined particle size,

(d) centrifugal cleaner means connected to receive such slurry and to separate the same into accepted material including substantially all organics and rejected material including the majority of the inorganic particles in said slurry, and

(e) screening means connected to receive the accepted material from said cleaner means and adapted to reject therefrom the relatively coarse organic particles while retaining at least the major portion of the paper fibers of papermaking size ranges therein.

32. Apparatus as claimed in claim 31, including

(f) primary fiber selecting means connected to receive the accepted material from said screening means and to separate the majority of the paper fibers of predetermined maximum lengths from the balance of said material, and

(g) further fiber selecting means connected to receive said balance of said material from said primary fiber selecting means and to separate the majority of the paper fibers of at least one other predetermined length range from the fines and other small particles remaining in said material.

33. Apparatus as claimed in claim 32, comprising additional centrifugal cleaner means connected to receive the accepted material from said screening means and to reject therefrom irregularly shaped particles similar to paper fibers in specific gravity and maximum dimension while transmitting the majority of the paper fibers therein to said fiber selecting means.

34. Apparatus as claimed in claim 32 or 33, wherein said primary fiber selecting means comprises means for separating the majority of the paper fibers normally retained on 35-mesh wire, and wherein said further fiber selecting means comprises means for separating the majority of the paper fibers normally retained on 100-mesh wire.

35. Apparatus as claimed in claim 32, 33 or 34, comprising means for purifying paper fibers connected to receive the paper fibers separated by at least one of said fiber selecting means.

36. Apparatus as claimed in claim 31, wherein said screening means comprises a relatively coarse screen connected to receive the accepted material from said cleaner means and adapted to reject therefrom the relatively coarse organic particles and a substantial portion of the paper fibers therein, and a relatively fine screen connected to receive the material accepted by said coarse screen and to reject therefrom a substantial portion of the paper fibers and of the other organic particles accepted by said coarse screen, and including additional means connected to receive the accepted material from said fine screen and to eliminate therefrom the majority of any remaining nonfibrous material.

37. Apparatus as claimed in claim 36, wherein said additional means comprises fiber selecting means connected to receive the accepted material from said fine screen and to reject therefrom the majority of small particles including paper fibers having a maximum dimension less than approximately one millimeter while accepting the majority of the paper fibers of longer lengths.

38. Apparatus as claimed in claim 37, comprising further centrifugal cleaner means connected to receive the accepted stock from said fiber selecting means and to reject therefrom irregularly shaped particles similar to paper fibers in specific gravity and maximum dimension.

39. Apparatus as claimed in claim 27, comprising digester means connected to receive the material accepted by said further centrifugal cleaning means and to treat the same under heat and pressure conditions effecting the dissolving or dispersion of at least the majority of particles other than paper fibres remaining therein.

40. The methods of reclaiming paper fibers from municipal refuse, substantially as hereinbefore described with reference to the accompanying drawings.

41. Apparatus for reclaiming paper fibers from municipal refuse, substantially as hereinbefore described with reference to the accompanying drawings.

42. Paper fibers when reclaimed by the methods process claimed in any one of claims 1 to 30 or 40 or by the apparatus claimed in any one of claims 31 to 39 or 41.

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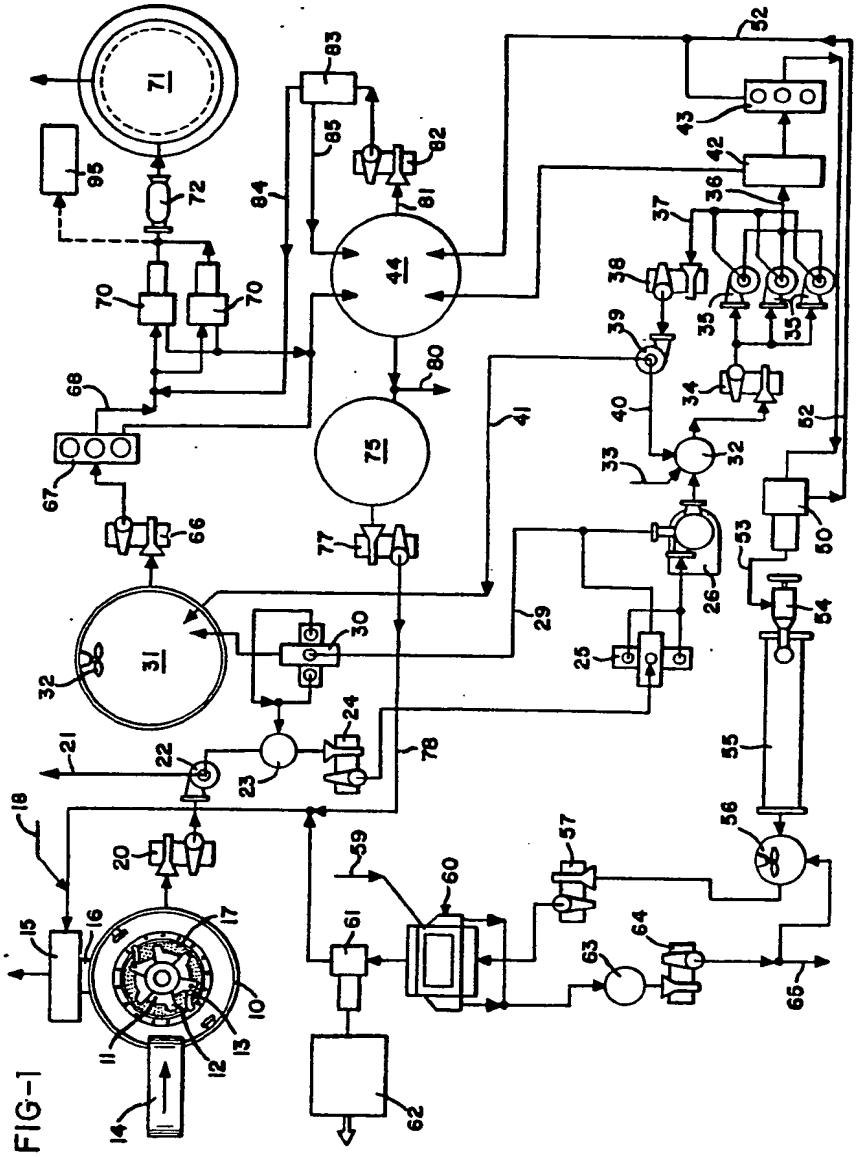


FIG-1

FIG-2

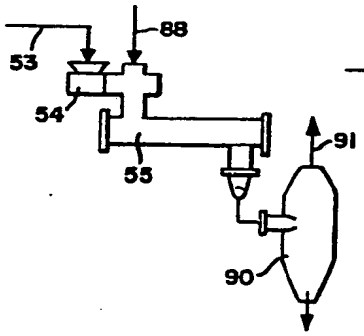


FIG-3

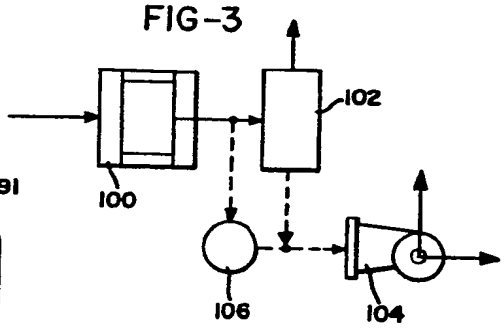
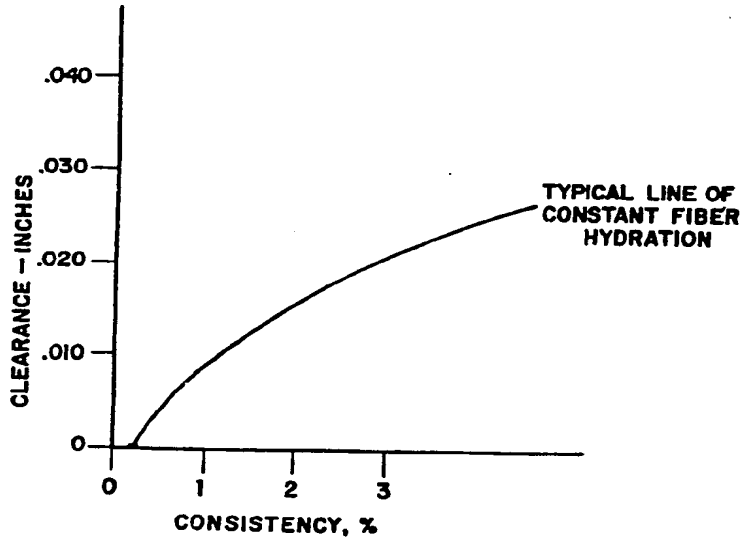


FIG-4



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3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 3

FIG. 5